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RESEARCH PAPER

Getting Trees Into Farmers' Fields: Success of Rural Nurseries in Distributing High Quality Planting Material in Cameroon

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Abstract Availability of high quality tree planting material within proximity of farmers and at affordable prices is one of the prerequisites for larger uptake of tree cultivation. This study examines whether rural small-scale nurseries can produce a diversity of tree planting material and whether resource-poor farmers have access to it. Twelve nurseries supported by the tree domestication program in the West and North-west regions of Cameroon were compared to 12 nurseries in similar conditions, but not in contact with the program. Nurseries using the domestication approach were found to provide tree planting material that responds better to farmers' needs in terms of quantities, species and propagation methods used. Their clientele is more diverse including farmers from the communities where the nurseries are located, but also from far beyond. However, prices of vegetatively propagated material were considered the most prohibitive factor. It is concluded that tree planting initiatives should refocus efforts towards technical training and business support to small-scale nurseries to increase efficiency. Research efforts should look for ways of reducing production costs and improving nursery productivity.

Keywords Agroforestry · Efficiency · Seedling supply · Tree domestication · Vegetative propagation

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Introduction

Throughout the humid tropics of West and Central Africa, rural populations have been using woody species for nutritional, health and construction needs. With developing markets a number of these species have also become important sources of income, especially for the poorest in rural areas. However, with rapid population growth and deforestation, these resources have been depleted, thus limiting livelihood options for the poor. Faced with these challenges, farmers have begun integrating local trees into their farming systems, but have been constrained by insufficient knowledge on propagation techniques and the management of these trees in combination with other annual and perennial crops. Several authors (Place and Dewees 1999; Bohringer et al. 2003; Roshetko et al. 2008; Andreasen and Boland 2008; Lillesø et al. 2011) have identified the availability of tree planting material of suitable quality, in sufficient quantities, within proximity of farmers and at affordable prices as a prerequisite for larger uptake of tree cultivation, as is illustrated by the conceptual framework in Fig. 1.

In the 1970s and 80s, large central nurseries managed by governments, research institutes, NGOs or in some cases individuals, were the only sources of tree planting material. However, these central nurseries have not succeeded in promoting tree planting materials as was expected, because their offer most often did not match smallholder needs in terms of species' diversity and field adaptability, but was rather determined by national and international priorities (Kerkhop 1989; Jaenicke 2001; He et al. 2012). As a result, the total number of tree seedlings produced was often below expectations, in spite of considerable investments. The distribution of these plants from the central nursery to (far-away) places suitable for tree planting was not only costly, but often considerably reduced the survival rate of the plants. Furthermore, the number of trees effectively planted in farmers' fields was low and

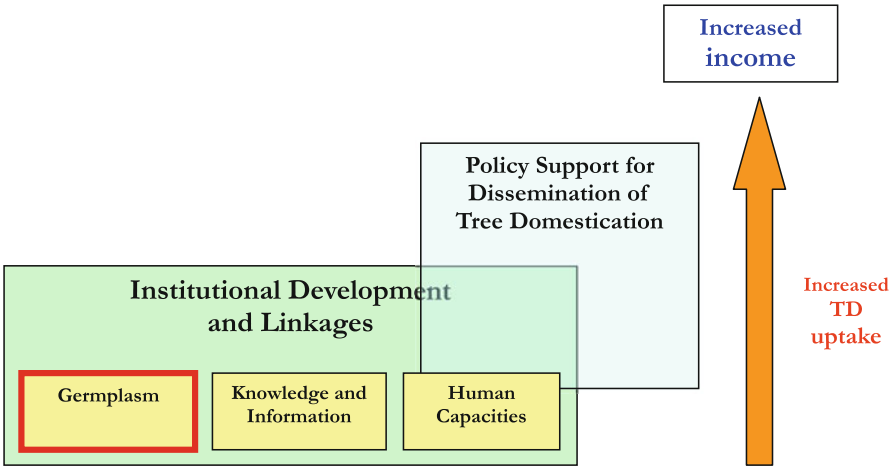

Fig. 1 Conceptual framework showing importance of quality germplasm in the uptake of tree domestication (TD) innovations

even when planted, their mortality rate was often high not only from lack of maintenance but also due to the low quality of the materials used.

Many of these problems can be attributed to insufficient involvement of local communities from the beginning of the project when tree species for reforestation were selected through to planting and care of the trees on community or individual land. One of the alternatives would be to build farmers' capacities to produce their own planting material. For example, Nyoka et al. (2011a) found that more than 90 % of the documented agroforestry tree seed distributed to farmers in Malawi was produced by smallholder farmers and collected mainly from scattered farmland trees. These authors concluded that the procurement and distribution of germplasm to farmers was in general effective, but that sustainability could be enhanced by strengthening grassroots organisations involved in tree seed and seedling production to institutionalize the distribution through farmer–farmer exchange. Similar needs for training of small-scale nursery operators in germplasm collection methods were highlighted by Carandang et al. (2006), Harrison et al. (2008) and Dawson et al. (2009) in other parts of the world.

In Cameroon, few studies have examined distribution channels for tree planting materials, and basically none examined agroforestry tree species or their supply in rural areas. Kouodiekong (1998) for example estimated that the market for fruit trees in the town of Yaounde between 1996 and 1998 was 74,037 plants of citrus, safou (*Dacryodes edulis*), mango and avocado. Nkana Ntea (2003)in 2001 estimated the sales of fruit trees in Yaounde as between 24,087 and 25,847 plants. This author concluded however that despite a production capacity of 33,243–34,543 plants, demand was not met because clients did not always find what they wanted in terms of quality and species range.

In general, three types of actors can be distinguished in the tree seed and seedling supply system in Cameroon. One is made up of governmental and non-governmental institutions, either research (e.g. IRAD[1]) or development-oriented (ANAFOR,[2] SAILD[3]). Another is private enterprises specialised in agricultural seed production (e.g. SOCASEM[4] and AfriSem), while the third category consists of small tree nurseries, mostly run by individuals in urban centres and by farmer groups in the framework of tree planting projects. All three categories tend to focus on a limited number of exotic fruit species and target mainly urban clients.

Tree domestication,[5] being a participatory process where farmers engage in all steps of tree selection, multiplication, integration and marketing, is offering an alternative approach to tree planting and is expected to overcome some of the difficulties highlighted above (Leakey and Simons 1998; Tchoundjeu et al. 2006; 2008). By doing so, it is expected that farmers would increasingly have access to high quality tree planting material of their choice by either joining nursery groups or

[1] Institut de Recherche Agricole pour le Développement (IRAD).

[2] National Forestry Development Agency (ANAFOR).

[3] Service d'Appui aux Initiatives Locales (SAILD).

[4] Société Camerounaise de Semences (SOCASEM).

[5] Tree domestication has been defined as an accelerated and human-induced evolution to bring species into wider cultivation through a farmer-driven and market-led process (Simons 1997).

by buying plants from small-scale nurseries within reasonable distance from their homesteads.

History of Nursery Development Under the Tree Domestication Program in Cameroon

Research on tree domestication in Cameroon commenced in 1998 with the development of simple and robust techniques appropriate for application within remote communities, including for example the poly-propagator for rooting of cuttings which does not require running water or electricity (Leakey et al. 1990; Mbile et al. 2004). To implement these vegetative propagation techniques in rural areas, community nurseries were established in pilot villages with the help of local NGOs, and groups of farmers were trained in a range of tree propagation techniques, such as the rooting of cuttings, marcotting and grafting. At the beginning, plant production in those nurseries was low and plants were shared among members for planting in their farms. After some years, some nurseries progressively had surplus and started selling their plants to other farmers, but more importantly to elites and business people who wanted to create fruit orchards in their native villages. There has been an increase in the number of nurseries that generated revenue from the sales of plants. In 2004, only 12 nurseries were able to generate income in Cameroon, whereas in 2006, 46 out of 111 nurseries reported to have generated some cash from their nursery enterprise (ICRAF-WCA/HT 2007). Also, the total income in 2006 was more than tenfold the income in 2004 (ICRAF-WCA/HT 2007). This can be explained by the increase in the number of nurseries generating revenue, as well as by the rise in average income per nursery (from 123,192 FCFA[6] per nursery in 2004 to 346,537 FCFA per nursery in 2006). In response, there was a need to make these small-scale nurseries more professional to meet the increasing demands for high quality planting material. To that effect, nursery operators in addition to receiving technical assistance were trained in enterprise development (Kana 2006; Tabuna et al. 2009). In some cases, the program facilitated the creation of nursery networks with the objective of sharing information, skills and germplasm between the nurseries (Kana 2009).

From 2006, another development took place with the aim of stepping up the wider dissemination of tree domestication practices. Some of the most promising nurseries, apart from being solely experimental and production units, became genuine centres for training, demonstration and diffusion of tree propagation in their respective areas. These centres, called *rural resource centres*, are managed by a lead NGO or Community-Based Organisation and are focal points where farmers gather to receive information and training on a wide range of skills. A rural resource centre typically backstops 10–25 satellite nurseries.

[6] FCFA: CFA francs, where CFA stands for *Communauté Financière Africaine* (African Financial Community) ; 656 FCFA $\approx$ 1€ and 500 FCFA $\approx$ 1 USD.

Over the years, the number of village nurseries in Cameroon had increased steadily from 6 in 1998 to over 200 in 2009 (Tchoundjeu et al. 2010). This evolution suggests that such a network of small-scale tree nurseries in rural areas could facilitate access of resource-poor farmers to improved tree planting material. Farmers could join nursery groups to learn tree propagation techniques and to benefit from plants produced in the group nursery. Alternatively, they might prefer to purchase improved planting material of their choice in small-scale nurseries, not too far from their homes.

Despite the increasing number of small-scale tree nurseries, it was timely to verify whether these nurseries are actually producing a diversity of tree planting material of high quality that is affordable by and accessible to resource-poor farmers. While individual nursery production has been recorded all this time and previous studies examined the technical feasibility and financial profitability of such nurseries (Degrande et al. 2006), little is known about the impact of this strategy on the availability of improved germplasm and farmers' tree planting practices. Consequently, a study was initiated in 2008 to evaluate the success of small-scale rural nurseries in the production and distribution of improved tree planting material in the western highlands of Cameroon. Specific objectives were to: (1) inventory and characterize small-scale tree nurseries; (2) assess quantitative and qualitative seedling production; (3) evaluate services provided by nurseries; and (4) determine geographical coverage of seedling supply.

The Study Site

The study was carried out in four divisions of the West and North-West regions of Cameroon belonging to the sub-humid highlands (Table 1). The topography of the area is undulating and the vegetation is predominantly moist savannah with patches of sacred groves, gallery and mountain forests containing a range of agroforestry tree species. The climate is unimodal with average annual rainfall ranging from 1,800 to 2,200 mm with the peak occurring in September. Daily temperatures vary from 10 to 28 °C with an average of 18–20 °C. Population density is medium to high (99.9 inhabitants/km^2 in the North-West region and 123.8 inhabitants/km^2 in the West region, as reported by BUCREP (2010). Some sloping areas are not suitable for farming at all, therefore increasing the pressure on arable land. Farm size averages 1.8 ha and intensive crop-livestock production characterises the agricultural production systems of the area. About half of the total surface area is planted with annual and perennial crops—cereals, legumes, root crops, horticultural crops, indigenous and exotic fruit tree crops, and cash crop including coffee, cocoa, tea and oil palm—which provide most of the income to rural households, though supplemented by livestock in some areas (Minang 2007). Fallow periods are generally less than 1 year. Market access is reasonably good in areas close to urban centres (including Bamenda, Bafoussam, Dschang) having acceptable road infrastructure, whereas other areas are characterised by poor roads and only have periodic markets.

Table 1 Study sites and nurseries from which information was collected

Region	With ICRAF intervention			Without ICRAF intervention		
	Village	Number of group members	Date of creation	Village	Number of group members	Date of creation
West	*Nde division*			*Haut-Nkam division*		
	Feutap	7	2004	Badoukam	1	1995
	Bangoulap	9	2003	Bakassa	1	2000
	Famveu	4	2005	Bana	1	2006
	Badiangseu	2	2005	Bakou	2	2006
	Batchingou	1	2006	Fotouni	1	1998
	Maham	6	2004	Kekem	2	2006
North-West	*Boyo division*			*Mezam division*		
	Belo	29	1993	Manbu	2	2002
	Mulombo	11	1998	Damekon	1	2002
	Atukone	19	1997	Medankwe	10	2001
	Kuikfuini	5	2003	Mankon	5	2003
	Dichami	7	2003	Bafut	3	1999
	Djinfuin	9	2004	Bambui	2	1998

Source: Tadjo Folack (2008)

Research Method

Assessment of Nursery Success

In 2009, 12 small-scale nurseries supported by the participatory tree domestication program (also referred to as ICRAF intervention) were selected for this study and compared with 12 nurseries in similar conditions, but not in contact with the program in the West and North-West regions of Cameroon. The support given by the participatory tree domestication program implemented by ICRAF included the provision of high quality founder germplasm, training in tree propagation and enterprise development, small nursery tools and facilitation of networking and exchanges between nurseries.

The location of the studied nurseries is shown in Fig. 2. The 4 sites met the same criteria, including sound road network, presence of both non-governmental and governmental extension support and similar climatic and topographic conditions.

The success of small-scale nurseries was evaluated in terms of quantities of seedlings produced, species diversity and client satisfaction. Information was thus collected on the quantity and quality of planting material produced, drawing on records kept by the nursery groups for the past 3 years (2005–07). It was recognized that these data may lack accuracy because farmers are not accustomed to record keeping. The assumption was that the records underestimate actual production, because plants can be given out to other farmers for free without being recorded. Where possible, production data were cross-checked with the extension agents. From each nursery, five clients were randomly interviewed from each of the

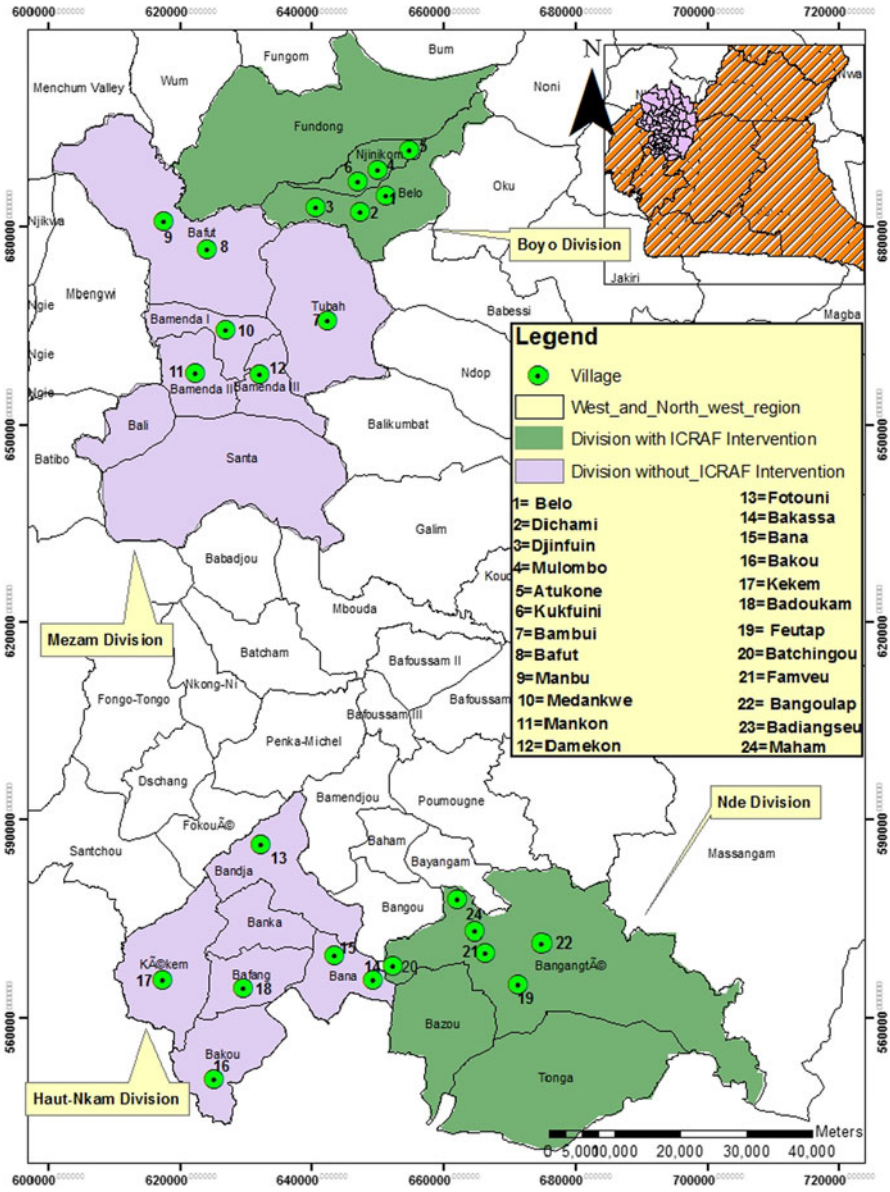

Fig. 2 Location of studied tree nurseries. *Source:* Prepared by Ngaunkam, GIS specialist at ICRAF, Cameroon

following categories: members of the nursery group, non-member farmers living in the village and elites from the village and institutions (projects, hospitals, schools and councils) to elicit their perceptions of price, quality, quantity, timing of delivery and after-sales' service. Satisfaction was evaluated on a four-point scale (1 = not satisfied at all, 2 = somewhat satisfied, 3 = satisfied, 4 = very satisfied). At the

same time, 10 farmers living in the village but who had not yet bought plants from the nursery (called *non-clients*) were asked to explain why. The combination of data collection tools used is summarized in Table 2. The data were entered and analysed in Excel.

Plant Quality in Nurseries

Subsequent to the survey on nursery performance, a study on seedling quality management was carried out from April to September 2010 by Kana Nguemo (2010). This study was conducted in 10 nurseries in the West and North-West regions and focused on vegetatively propagated plants of 2 exotic species (*Persea americana*, *Mangifera indica*) and 3 indigenous species (*Dacryodes edulis*, *Cola nitida* and *Prunus africana*). Nurseries were randomly selected amongst those that had received support from the tree domestication program for at least 5 years. The parameters measured, on 181 plants, included plant height, collar diameter, number of leaves and of branches. Simple observations were also made on stem deformities and general health status. Information was collected on the origin of the material used in order to evaluate to what extent nursery operators respect germplasm collection guidelines and select superior trees for multiplication.

Results

Germplasm Support Activities

One of the most important activities that support seed and seedling systems is technical skill development (Harrison et al. 2008). A decentralised system of small-scale nurseries in Cameroon is feasible because participatory tree domestication

Table 2 Data collection tools used and target population by objective

Objective	Information needed	Data collection tools	Target group (numbers)
Inventory and characterize	Organisation, maintenance, infrastructure and tools	Checklist; nursery records; observations	Nursery managers (24)
Assess plant production	Number of plants and species produced; multiplication techniques	Checklist; production records	Nursery managers (24)
Evaluate services provided	Client satisfaction; post-sales service	Questionnaire; list of clients; discussions and observations; nursery sales book	Clients (197); non-clients (197); nursery managers (24)
Determine geographical coverage	Distribution zone; type and origin of clients	Questionnaire; list of clients	Clients (197); nursery managers (24)

empowers farmers to identify (based on farmer preferences, market opportunities and biophysical suitability), select and propagate their best trees in rural nurseries (Tchoundjeu et al. 2006). The emergence of a network of small-scale nurseries in Cameroon, however, has been the result of a series of efforts including technical and material support. ICRAF's research on germplasm improvement has led to the development of vegetative propagation techniques for a number of indigenous species of high value to farmers. The work on germplasm collection and characterisation has facilitated the production of high quality base germplasm for various species, including *D. edulis*, *Irvingia gabonensis*, *Garcinia kola*, *C. nitida* and *Ricinodendron heudelotii*. Rural resource centres were supported to create mother blocks with a view to facilitating access to selected germplasm at low cost for nursery operators in the area. These mother blocks are collections of trees with desired characteristics from which cuttings, scions or marcotts can be harvested for mass propagation.

ICRAF through its various donor-funded tree domestication projects, was also able to *support the establishment and running of small-scale nurseries*. More specifically, the process of nursery development started with the identification of areas with high potential for tree domestication. After sensitisation and information, meetings were held with interested farmer groups to agree on the concept and strategies for tree domestication. In those meetings, it was agreed that the farmer group which decided to create a nursery would receive from ICRAF a 'nursery starter kit' consisting of some nursery tools not affordable by farmers. ICRAF also in some cases provided material and technical guidance for the construction of non-mist propagators when the group wanted to engage in rooting of cuttings or humidity chambers in case of marcotting. All other materials were provided by the farmers, who were in addition responsible for the day-to-day running of the nursery. To assure sustainability of the activity, no financial incentive was given to any of the nursery operators. In some cases it also occurred that the farmer group already had a tree nursery but wanted to diversify its production with local species or take on vegetative propagation.

Once nurseries were created, *training* in elementary nursery and vegetative propagation techniques (rooting juvenile cuttings, grafting and marcotting), as well as planning of nursery production and group dynamics were gradually introduced to the farmer groups. To capitalize on the achievements of successful nurseries, *exchange visits* were organised to expose new groups to the experiences and achievements of older groups involved in tree domestication. Another means of increasing farmers' interest was the organisation of *best nursery competitions* and publicising results through media. People in neighbouring villages were keen to become involved and trained farmers were encouraged to help and train their neighbours, friends and family in the basic techniques of nursery management and tree selection. This spontaneous transfer of knowledge and skills was further stimulated through the intervention of relay organisations. Relay organisations are community-based organisations involved in agroforestry extension and make the link between research organisations such as ICRAF and farmer communities (Degrande et al. 2012). After having received training from ICRAF, relay organisations identified interested farmer groups in their respective areas and

conducted training on tree propagation. All these nurseries were then visited by the relay organisation at least once every 2 months during which *technical*, *material and organisational assistance* was provided where necessary. ICRAF, in the company of a technician from the relay organisation, also conducted field visits to a sample of these small-scale nurseries in order to identify bottlenecks and look together for solutions. This technical assistance was provided over a period of 2–3 years to allow the nursery operators to go through a minimum of two production cycles and put into practice skills acquired during various trainings on a learn-by-doing basis.

Another activity that supports seed and seedling systems is business support (Graudal and Lillesø 2007). It was noticed that some of the groups operating small-scale nurseries started selling their surplus seedlings 2–3 years after their creation. However, most of them lacked the business skills that are required to turn a 'subsistence-oriented' nursery into a 'viable enterprise'. Therefore, training sessions on enterprise development were organised with modules on leadership, marketing strategies, financial management and the development of a business plan. As an example, business plans were developed for four nurseries in Cameroon, considered having the greatest commercial potential and representing distinct agro-ecological zones. In addition to production and financing plans, the business plans included forecasts of the demand for improved germplasm. From these case studies a practical manual, which guides the development of a nursery business plan step by step, has been developed and made available to nursery operators and relay organisations.

ICRAF and relay organisations also actively promoted the products and services of small-scale nurseries through media and public events. Whenever there was an opportunity, they facilitated linkages between nurseries and potential clients. In some cases, the creation of nursery networks to stimulate exchanges of information, experiences and germplasm, was facilitated, e.g. by UGICANE (Union des GICs Agroforestiers du Ndé) in Ndé division and CAWAFNET (Cameroon Western Highlands Agroforestry Network) for the West and North-West regions of Cameroon.

Success of Small-Scale Nurseries

The extent of success of small-scale nurseries was assessed in terms of quantities of seedlings produced, species diversity and client satisfaction. As revealed in Fig. 3, the total number of plants sold for the period 2005–07 was higher in the nurseries within ICRAF's intervention zone (Boyo and Nde), than in nurseries with no links to ICRAF (Mezam and Haut-Nkam). There were no significant differences between the destination (selling, planting or sharing) of the plants of nurseries with and without ICRAF intervention. However, the proportion of the production that was planted by members of the nursery groups in the North-West (15 %) was double that in West region (7 %) and the number of trees planted per group member decreased with increasing group size. For example, over the 3 year period, nurseries in Boyo division (80 members) had a record of 316 trees planted on average per member, while in Haut-Nkam (8 members only) 896 trees were planted per

member. This can be explained by higher population density and prevailing land tenure arrangements which constitute barriers for wider tree cultivation in the West region.

In terms of species diversity, nurseries under the tree domestication program had a greater number of tree species and more often used vegetative propagation methods. For example, from the 22 tree species recorded in nurseries in the West region, nurseries in Haut-Nkam (outside ICRAF intervention zone) produced only 8 species (Table 3). None of the nurseries in Haut-Nkam and Mezam multiplied by rooting of cuttings and only one nursery had produced 15 grafted plants and 30 marcotts between 2004 and 2007. The source of the material used in plant production was more diverse in nurseries under the tree domestication program. In addition to non-selected vegetative material and seeds obtained from fruits with desired characteristics that were used by all nurseries, nurseries in Nde and Boyo division sourced their stock plants, scions and seeds from research centres (in particular ICRAF and IRAD) and often shared material with other nursery groups through nursery networks.

Finally, evaluation of nursery success was done in terms of client satisfaction. Clients of smallholder tree nurseries in the study sites can be placed in 4 categories: members of the nursery groups; other farmers in the community or neighbouring villages who are not members of the group; elites from the village who wish to invest in tree cultivation; and institutional clients including projects, hospitals, schools and councils promoting tree planting and usually placing orders of tree seedlings. The clientele of nurseries with ICRAF intervention was found to be more diverse, including farmers from the communities where the nurseries are located, but also from far beyond. Nurseries not benefiting from ICRAF intervention relied largely on institutional clients and planned their production according to the orders placed.

As shown in Fig. 4, clients of nurseries benefiting from ICRAF's intervention had a higher level of satisfaction in terms of quality, propagation method, quantity

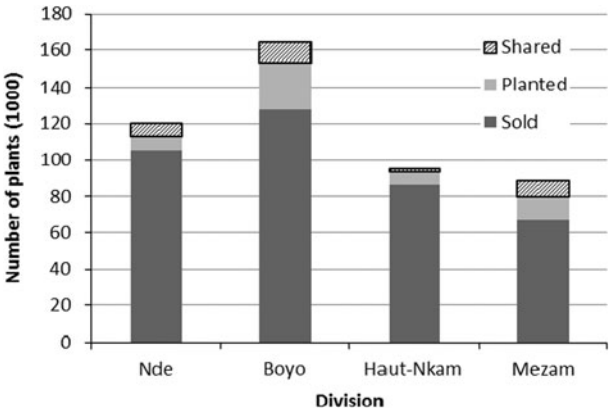

Fig. 3 Total number of plants sold (Sold), planted by group members in their farms (Planted) and distributed free of charge to other beneficiaries (Shared) over 3 years (2005–07) for the 6 nurseries studied in respectively, Nde, Boyo, Haut-Nkam and Mezam division

Table 3 Relation between tree species present in farms, demanded by clients and produced in nurseries in West province

Species	Nde division (in TD program)			Haut-Nkam division (NOT in TD program)		
	Present in farms	In demand by clients	Produced in nurseries	Present in farms	In demand by clients	Produced in nurseries
Calliandra calothyrsus	x	x	x	x	x	x
Canarium schweinefurthii	x	x	x		x	
Citrus spp.		x	x	x	x	x
Cola sp.	x	x	x		x	
D. edulis	x	x	x		x	x
Elaeis guineensis		x	x		x	
Fagara		x	x	x		x
Leucaena leucocephala		x	x		x	
M. indica	x	x	x			
Monodora myristica		x	x		x	
Persea americana	x	x	x			
Pinus sp.	x	x	x	x	x	x
Piper sp.		x	x	x		x
P. africana	x	x	x		x	
Psidium guajava		x	x		x	
Ricinodendron heudelotii		x	x	x		x
Tetrapleura sp.		x	x		x	
Voacanga sp.		x	x		x	

and timing than clients from nurseries outside ICRAF's intervention zone. The former were also found to be more satisfied with the post-sales' services rendered, including technical information, assistance with planting and replacement of dead plants. Nevertheless, prices of vegetatively propagated material, especially marcotts, were considered too high by the majority of clients and were the most prohibitive factor for non-clients as well.

Plant Quality in Nurseries

In terms of the origin of plant material used for propagation, 85 % of the nursery operators interviewed collected material from selected trees on their own or neighbours' farms, 12 % bought seeds on the market and 3 % obtained material from ICRAF. The number of trees from which material was collected depended on the species, but was generally lower than the recommended 30 trees. Only for marcotting of *D. edulis*, had nursery operators used 30 trees per season on average.

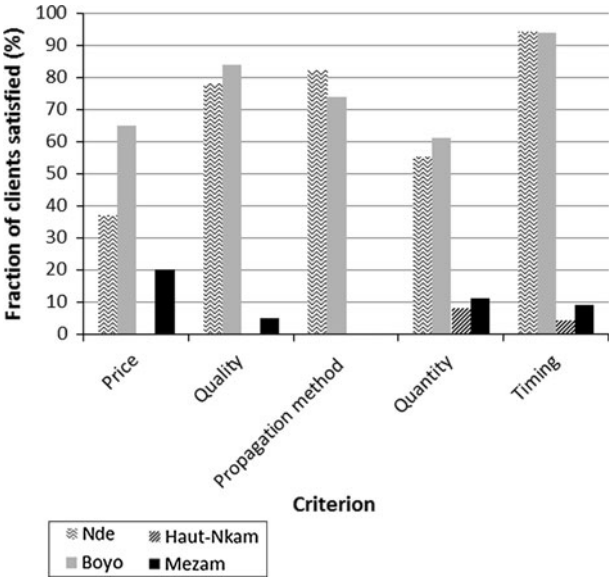

Fig. 4 Client satisfaction in nurseries within ICRAF intervention zone (Nde and Boyo division) and outside ICRAF intervention zone (Haut-Nkam and Mezam division)

However, it was noticed that the longer nurseries had been in business, the greater the number of trees from which material was collected, suggesting a growing level of awareness on the importance of spreading the genetic basis for tree propagation. This is also consistent with the findings that 70 % of the nurseries studied changed the origin of germplasm from one year to another. Main reasons for this were the search for new varieties, avoiding destruction of mother trees (especially for marcotting) and inaccessibility of trees on which germplasm was previously collected. The insufficient attention to genetic aspects of germplasm is also reflected by the fact that only 35 % of the nurseries labeled their plants and documented the origin and characteristics of the mother trees. However, nursery operators did mention they select mother trees using the following criteria, in order of importance: fruit taste and size; pests and disease resistance; and regularity in fruiting.

In the opinion of nursery operators, the deep green colour of leaves was the most important sign of high quality plants, followed by absence of pests and diseases, stem straightness and rapid growth. This notwithstanding, pests and diseases were identified as the most important problem in 35 % of the nurseries. In fact, all plants of *M. indica*, 64 % of *P. africana* and 62 % of *C. nitida* plants found in the nurseries surveyed showed important phytosanitary problems caused by either fungi (black and white spots on leaves) or insects (perforation and drying of leaves). In this respect, nursery operators most often complained about the high costs of pesticides, but some said they did not think the pests and diseases were severe enough to affect plant growth once transplanted in the field. Apart from *P. africana*, the other species (*D. edulis*, *C. nitida*, *M. indica and P. americana*) had a sturdiness coefficient of less

than 6, indicating robust plants. *M. indica* on the other hand had many stem deformations.

Discussion and Policy Implications

Differences were detected in the success of small-scale tree nurseries in terms of quantities of tree seedlings produced, species diversity and client satisfaction. Nurseries assisted by ICRAF's tree domestication program, and therefore having received considerable technical, material and business support, generally produced more plants than those operating without ICRAF intervention. One could argue that the higher production is to be attributed to the greater level of support received from ICRAF. As a matter of fact, non-ICRAF nurseries certainly received less technical assistance, although there was evidence that they also obtained some support from other organisations. On the other hand, the destination of plants produced—i.e. for sales, planting by members or sharing free of charge—was more or less the same in both categories. The fact that between 10 and 30 % of the production was shared between members or distributed free of charge is an important aspect of small-scale nurseries, because it provides opportunities for resource-poor farmers to have access to planting material without cash transactions. The conclusion here would be that the more members in a nursery group, the higher the number of people who can benefit from the plants produced. However, nursery production was found to decrease with increasing group size, which is consistent with earlier findings by Mbile et al. (2004). This suggests that there would be an optimal size for nursery groups. For small-scale nurseries to be efficient in providing planting material to resource-poor farmers, a balance is therefore required between nursery objectives (sales vs. sharing free of charge), number of plants produced and group size.

The greatest advantage of participatory tree domestication lies in the strengthening of farmers' capacities to propagate species of their choice (Tchoundjeu et al. 2010). This explains the much higher number of species found in nurseries under the tree domestication program as compared to those operating without ICRAF intervention. In addition to farmers' improved propagation skills, the tree domestication program has increased people's awareness on the utility of local species and the importance of tree diversity on farm, which may also explain the diversity in nurseries in ICRAF's intervention zone. Proximity to their clients and the fact that they are not exclusively profit-making but also produce for their members further explains why these nurseries do not limit species to those in high demand. Similar findings were reported by Nyoka et al. (2011a) in Malawi and He et al. (2012) in China.

Greater species' diversity and the availability of a range of propagation techniques producing trees with particular growth characteristics and fitting various niche requirements most probably explain the higher satisfaction level among clients of tree domestication nurseries. Another important factor for higher client satisfaction was post-sales' services in the form of technical information, assistance with planting and replacement of dead plants, rendered by ICRAF nurseries. This

can be explained by the technical knowledge of nursery operators that was significantly improved during training and subsequent follow-up visits.

The importance of technical knowledge and skills in nursery operations, described by several authors elsewhere (e.g. Graudal and Lillesø 2007; Harrison et al. 2008; Roshetko et al. 2008), highlights the significant contribution of germplasm support activities. The findings of this study suggest that a decentralised tree seed and seedling system is feasible, but requires a large amount of technical as well as business support. Close monitoring of nurseries in Cameroon by both relay organisations and ICRAF for a period of at least 2 years has proven to be necessary in order to upgrade continuously the technical skills of nursery operators and detect and fix bottlenecks as soon as they arise. Although not specifically examined in this study, it appears that nurseries engaged in participatory tree domestication are not purely profit-oriented and this feature facilitates access of resource-poor farmers to high quality planting material. This issue however, together with the need for substantial capacity building, raises questions about the sustainability of the system in the absence of donor support in the long run. Nevertheless, there is scope for improving government policies regarding tree planting to support small-scale nurseries through technical training and business aid. It is desirable that reforestation, afforestation and other tree planting initiatives adopt this approach so that small-scale nurseries in rural areas can ensure the delivery of improved tree planting material to resource-poor farmers. In this process, they can use trained relay organisations and existing rural resource centres for production, demonstration, training and diffusion purposes. With a view of improving sustainability of smallholder nurseries, there is also need to assist them with the development of marketing strategies and their search for clients. One means to ensure regular demand would be for government programs to contract out seedling production to smallholder tree nurseries in rural areas, rather than producing seedlings in centralised tree nurseries and then distributing free of charge. This could increase operating life and financial stability of small-scale rural nurseries. Harrison et al. (2008) and He et al. (2012) already recommended governments taking a greater role in working cooperatively with private nurseries by contracting out seedling production, rather than competing with them.

As in most of African countries (Nyoka et al. 2011b), there are no formal regulations on tree seed and seedling production in Cameroon, so that quality management is more or less self-imposed. The study on quality management in small-scale nurseries in Cameroon has shown that few nursery operators applied the basic quality standards required by most seed regulatory systems elsewhere. For example, less than one-third of the nursery operators interviewed systematically recorded the origin of the plant material used (such as seeds, cuttings and scions) or documented the characteristics of the mother trees. A high incidence of pests and diseases was detected in the nurseries, as well as problems with stem deformations for particular species. There is thus need to train extension staff and nursery operators on issues of germplasm quality, starting with creating more awareness on the importance of tree quality as a key criteria for seed source and mother tree selection, followed by simplifying and adapting germplasm collection guidelines to local conditions and training nursery operators in basic nursery practices for the

production of healthy plants (Roshetko et al. 2008). Government naturally has a role to play in quality control by developing appropriate seed and seedling regulations and certification schemes, as was also suggested by Nyoka et al. (2011b).

Conclusion

The participatory tree domestication program clearly has assisted small-scale nurseries in becoming more professional and more client-oriented. More specifically, nurseries involved in the tree domestication program produce plants all year round, whereas operation of nurseries outside the program is more seasonal. Tree domestication nurseries produce a higher diversity of species, exotic as well as indigenous, and make more use of vegetative propagation methods. Clients of the nurseries carrying out tree domestication are more satisfied in terms of quantity, quality, propagation method used and timing of delivery than those who purchase from nurseries outside ICRAF intervention zone. However, despite overall satisfaction of clients, plant quality management in these nurseries requires further attention. Moreover, the main bottleneck that limits farmers' access to high quality planting material is the price of the planting material.

There is need for researchers and the private sector to develop mechanisms to supply high quality founder germplasm of a range of species through the establishment of genebanks, mother tree blocks and seed orchards with superior material and also further investigate tree improvement and propagation techniques. It is also desirable that research organisations continue to look for ways of reducing production costs and improving nursery productivity to remove the price barrier that is still holding farmers from buying high quality planting material.

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References

Andreasen L, Boland D (2008) Getting better tree germplasm into the hands of smallholder farmers in developing countries—some lessons from agriculture. Forest Genetic Resources no 24. FAO, Rome, Italy. www.fao.org/docrep/008/w3354e/W3354E09.html, Accessed 16 April 2012

Bohringer A, Ayuk ET, Katanga R, Ruvuga S (2003) Farmer nurseries as a catalyst for developing sustainable land use systems in southern Africa. Part A: nursery productivity and organization. Agric Syst 77(3):187–201

BUCREP [Bureau Central des Recensements et des Etudes de Population] (2010) Rapport de présentation des résultats définitifs. www.statistics-Cameroon.org/downloads/Rapport_de_presentation_3_RGPH.pdf, Accessed 8 May 2012

Carandang WM, Tolentino EL Jr, Roshetko JM (2006) Smallholder tree nursery operations in Southern Philippines—supporting mechanisms for timber tree domestication. For Trees Livelihoods 16(1):71–83

Dawson IK, Lengkeek A, Weber JC, Jamnadass R (2009) Managing genetic variation in tropical trees: linking knowledge with action in agroforest ecosystems for improved conservation and enhanced livelihoods. Biodivers Conserv 18(4):969–986

Degrande A, Facheux C, Mfoumou C, Mbile P, Tchoundjeu Z, Asaah E (2006) Feasibility of farmer managed vegetative propagation nurseries in Cameroon. For Trees Livelihoods 16(2):181–190

Degrande A, Franzel S, Siohdjie Yeptiep Y, Asaah E, Tsobeng A, Tchoundjeu Z (2012) Effectiveness of grassroots organisations in the dissemination of agroforestry innovations. In: Kaonga M (ed) Agroforestry for biodiversity and ecosystem services—science and practice. InTech, Rijeka, pp 141–164

Graudal L, Lillesø J-PB (2007) Experiences and future prospects for tree seed supply in agricultural development support—based on lessons learnt in DANIDA supported programs 1965–2005. DANIDA Working Paper 2007. Ministry of Foreign Affairs of Denmark, Copenhagen

Harrison S, Gregorio N, Herbohn J (2008) A critical overview of forestry seedling production policies and practices in relation to smallholder forestry in developing countries. Small Scale For 7(3&4): 207–223

He J, Yang H, Jamnadass R, Xu J, Yang Y (2012) Decentralization of tree seedling supply systems for afforestation in west of Yunnan province, China. Small Scale For 11(2):147–166

ICRAF-WCA/HT (2007) Growing out of poverty: tree cultivation in West and Central Africa for home use and markets. Project Completion Report 2004–2007. TA Grant no 697-ICRAF. Yaoundé, Cameroon

Jaenicke H (2001) Innovative strategies for small scale tree nursery development. Working paper, ICRAF, Nairobi, Kenya

Kana PR (2006) Business plan pour le développement d'une pépinière rurale de production de plants améliorés d'arbres fruitiers. Mémoire soutenu en vue de l'obtention du diplôme d'études Supérieures de Commerces, Université de Douala

Kana Nguemo N (2009) Fonctionnement du réseau de pépiniéristes dans la Région de l'Ouest Cameroun: Cas du Département du Nde. Rapport de stage de pré-insertion professionnelle, Université de Dschang, Cameroun

Kana Nguemo N (2010) Evaluation des performances en pépinières et en plantations paysannes des plants d'arbres agroforestiers dans les zones de forêt et de savane humide du Cameroun. Mémoire de fin d'études présenté en vue de l'obtention du diplôme d'Ingénieur des Forêts, des Eaux et de la Chasse. Université de Dschang, Cameroun

Kerkhop P (1989) Agroforestry in Africa: the central role of nurseries. Panos Institute, London

Kouodiekong L (1998) Diffusion des plants fruitiers sélectionnés dans la province du Centre: Acquis et contraintes. Rapport de stage. Faculté des Sciences. Université de Yaoundé I, Cameroun

Leakey RRB, Simons AJ (1998) The domestication of indigenous trees in agroforestry for the alleviation of poverty. Agrofor Syst 38(1–3):165–176

Leakey RRB, Mesen JF, Tchoundjeu Z, Longman KA, Dick JMcp, Newton A, Matin A, Grace J, Munro RC, Muthoka PN (1990) Low cost techniques for the vegetative propagation of tropical trees. Commonw For Rev 69:247–257

Lillesø J, Graudal L, Moestrup S, Djær E, Kindt R, Mbora A, Dawson I, Muriuki J, Rœbild A, Jamnadass R (2011) Innovation in input supply systems in smallholder agroforestry: seed sources, supply chains and support systems. Agrofor Syst 83(3):347–359

Mbile P, Tchoundjeu Z, Degrande A, Avana ML, Tsobeng A (2004) Non-mist vegetative propagation by resource-poor rural farmers of the forest zone of central Cameroon: some technology adaptations to enhance practice. For Trees Livelihoods 14(1):43–52

Minang AP (2007) Baseline and program implementation plan: Agricultural and tree product program (food for progress 2006) USDA/MINPLADAT/ICRAF. ICRAF, Yaounde

Nkana Ntea B (2003) Etude des stratégies de distribution et de commercialisation des plants fruitiers locaux produits dans les pépinières rurales à proximité de Yaounde. Mémoire présenté en vue de l'obtention du Diplôme d'Ingénieur Agronome. Université de Dschang, Cameroun

Nyoka B, Mng'omba S, Akinnifesi F, Ajayi O, Sileshi G, Jamnadass R (2011a) Agroforestry tree seed production and supply systems in Malawi. Small Scale For 10(4):419–434

Nyoka B, Ajayi O, Akinnifesi F, Chanyenga T, Mng'omba S, Sileshi G, Jamnadass R, Madhibha T (2011b) Certification of agroforestry tree germplasm in Southern Africa: opportunities and challenges. Agrofor Syst 83(1):75–87

Place F, Dewees P (1999) Policies and Incentives for the adoption of improved fallows. Agrofor Syst 47(1–3):323–343

Roshetko JM, Mulawarman, Dianarto A (2008) Tree seed procurement-diffusion pathways in Wonogiri and Ponorogo, Java. Small Scale For 7(3&4):333–352

Simons T (1997) Tree domestication—better trees for rural prosperity. Agrofor Today 9(2):4–7

Tabuna H, Kana R, Degrande A, et Tchoundjeu Z (2009) Business Plan d'une pépinière rurale de production et de commercialisation des plants améliorés des produits forestiers non ligneux en Afrique centrale. ICRAF Working Paper. World Agroforestry Centre, Yaounde, Cameroun

Tadjo Folack Patrick Serge (2008) Evaluation de l'efficacité des pépinières rurales des zones d'intervention de l'ICRAF dans la distribution des plants d'arbres agroforestiers : cas des provinces de L'Ouest et du Nord-Ouest Cameroun. Mémoire présenté en vue de l'obtention du diplôme D'Ingénieur des Eaux, Forêts et Chasse. Faculté d'Agronomie et des Sciences Agricoles, Université de Dschang, Cameroun

Tchoundjeu Z, Asaah EK, Anegbeh P, Degrande A, Mbile P, Facheux C, Tsobeng A, Atangana AR, Ngo Mpeck ML, Simons AJ (2006) Putting participatory domestication into practice in West and Central Africa. For Trees Livelihoods 16(1):53–69

Tchoundjeu Z, Atangana A, Asaah E, Tsobeng A, Facheux C, Foundjem-Tita D, Mbosso C, Degrande A, Sado T, Kanmegne J, Mbile P, Tabuna H, Anegbeh P, Useni M (2008) Domestication, utilization and marketing of indigenous fruit trees in West and central Africa. In: Akinnifesi FK, Leakey RRB, Ajayi OC, Sileshi G, Tchoundjeu Z, Matakala P, Kwesiga FR (eds) Indigenous fruit trees in the tropics: domestication, utilization and commercialization. CABI International, Wallingford, UK, pp 171–185

Tchoundjeu Z, Degrande A, Leakey RRB, Nimino G, Kemajou E, Asaah E, Facheux C, Mbile P, Mbosso C, Sado T, Tsobeng A (2010) Impacts of participatory tree domestication on farmer livelihoods in West and Central Africa. For Trees Livelihoods 19(3):217–234